

## **Surf Zone Technology Lane Marking**

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### **LONG-TERM GOAL**

My long-term goal is to develop a robust lane marking system that will be used during an amphibious assault to delineate a breached lane through an obstacle/mine field in the surf zone and very shallow water. This marking system will be emplaced prior to the commencement of breaching operations and will be used by a variety of assault vehicles over a 72-hour period.

### **OBJECTIVES**

This year we wished to find a near term solution and decided to concentrate our effort on a visual type marker. Our objectives were three fold. First we wished to define a visual marker concept to meet the near term requirements and to identify several electronic marking concepts to meet future requirements. Second we wished to develop a visual marking system that can easily be emplaced by a diver at depths as great as 40 ft. Third we wished to demonstrate an inflatable foam injected buoy concept that would float even if punctured.

### **APPROACH**

First, LtCol. James Curry (USMC LNO) was to conduct a survey of the fleet to help define requirements. Donald Robeson, LtCol. Curry, and Donald Campbell attended several fleet working groups to discuss the marking problem. After requirements were established, Mr. Campbell, LCDR Brian Price (RAN), and Stephen Schelfhout developed several line and anchoring concepts and assisted in developing the CO<sub>2</sub> inflatable buoy concepts to be known as the diver inflatable lane marking system (DILMS). Los Alamos Technical Associates (LATA) was contracted to develop a proof of concept demonstrator model of an inflatable foam injected buoy (IFIB).

### *Diver Inflatable Lane Marking System*

A market survey was conducted to determine if commercial-off-the-shelf (COTS) products could be used or modified to meet the fleet requirements. After candidate systems were established, the buoys were tested in the 50-ft dive tower at the Naval Diving and Salvage Training Center (NDSTC) to ensure their capability of being deployed at depth and to determine their longevity. The anchors were tested at different locations around the Coastal Systems Station (CSS) to determine their ability to hold and ease of emplacement in varying soil types. Next, an open-water test was conducted in the Gulf of Mexico near Shell Island, FL.

Following outcome of the open-water test, the best candidate system would be given to the VSW/MCM detachment, Coronado, to use in the RIMPAC EAST 00 exercise. After the exercise, each diver would be given a questionnaire to rate the marking system. Modifications would be made based on diver comments and the system retested. Finally, a demonstration of the modified system would be conducted at Cypress Springs, FL.

LT Lisa Kestel (RAN) assisted Don Campbell in testing several modified anchors and in obtaining torsion requirements. John Sojdehei helped with identifying materials to meet the low- $\mu$  requirements and is investigating possible ways to remotely activate a marker buoy system. Jonathon Mitchell designed several 3D-solid models of a low- $\mu$  anchor. LT Edoardo Naggiar (USN SEAL LNO) provided inputs for the final auger anchor design.

### *Inflatable Foam Injected Buoy*

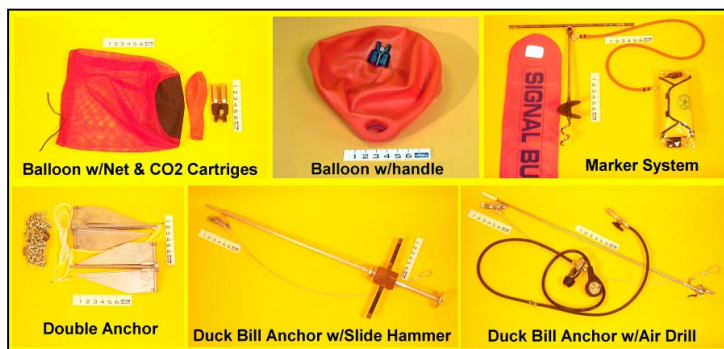
A team from LATA's Systems Analysis group undertook the design with design assistance and shop space provided by MIOX Corporation. The design uses a technology of pressure-forced extrusion of a binary rigid polyurethane foam (RPF) liquid from flexible reservoirs through a helical "static" mixer. The plumbing for the foam system was designed using John Guest® snap connectors and 0.25-inch (ID) plastic tubing. The system is powered when a CO<sub>2</sub> cartridge is discharged inside the pressure vessel to squeeze and empty the RPF liquid components through a static mixer assembly. Once, mixed, a chemical reaction takes place filling the buoy envelope with foam. The only parts in the initial design that were not COTS were the adapter caps for the chemical reservoirs and the union head cap to hold the CO<sub>2</sub> valve.

## **WORK COMPLETED**

### *Diver Inflatable Lane Marking System*

Representatives from the following communities were contacted: Advanced Amphibious Assault Vehicle (AAAV) program office, Assault Craft Unit (ACU) One and Five, 2<sup>nd</sup> Armored Amphibian Battalion, Beach Group One and Two, 1<sup>st</sup> and 2<sup>nd</sup> Combat Engineers, and the Very Shallow Water/Mine Counter Measures (VSW/MCM) detachment. After requirements were established we worked closely with the VSW/MCM detachment, Coronado, to develop a diver portable inflatable marking system. Buoy and anchor concepts are show in Figure 1.

Two spherically shaped inflatable balloon concepts were developed. The first concept used nylon net to house a balloon that would be inflated using two CO<sub>2</sub> cartridges. Three different balloon materials

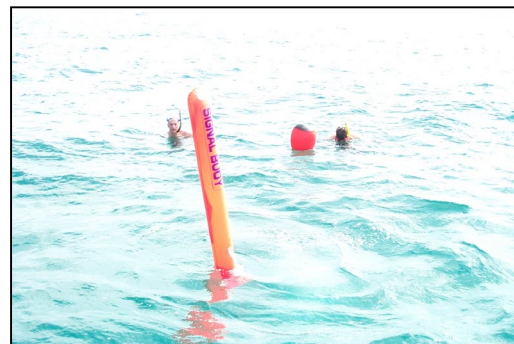


**Figure 1. Buoy and anchor concepts**

DUCKBILL anchor by Foresight Products, LLC, with a slide hammer insertion tool; and a modified DUCKBILL anchor with an air drill (aqua-jet) insertion tool. Two line types were investigated: ¼ in ID x 1/8 in wall x ½ in OD surgical tubing (bungee), and parachute chord.

Tests of the different buoys were made in the 50-ft dive tower at NDSTC and down selection were made. The remaining two buoy concepts and three line and anchoring concepts advanced to an open-water test. The open-water test (Figure 2) was conducted during April in the Gulf of Mexico near Shell Island, Florida from 0800-1530 CDT. Conditions for the test were: calm seas, winds 10-15 mph, and water depths of 22 ft and 32 ft. Down selections were made and the best concept was given to the VSW/MCM detachment, Coronado, for use in RIMPAC EAST 00.

After receiving the diver comments, modifications were made to the buoy. The buoy was retested in the 50-ft dive tower and a demonstration was conducted at Cypress Springs, FL. Several 3-D solid models of a low-μ auger anchor were made using Solid Edge 8.0 and a stereo lithography process. Also, modifications to the “aqua-jet” DUCKBILL anchor insertion tool were made and tested.



**Figure 2. Open-water test**

### *Inflatable Foam Injected Buoy*

LATA conducted experiments over a 2 ½ month period to verify the feasibility and determine the critical design parameters. A number of changes were made to the original design. In September two proof of concept demonstrator models were assembled and demonstrated at CSS Panama City, FL.

## **RESULTS**

### *Diver Inflatable Lane Marking System*

The combined notional marker characteristics are shown in Table 1. The Mylar and rubber balloons were quickly discarded because they frequently ruptured. The flexible polyurethane balloon and the double grappling anchor were discarded because they were too bulky. Both the triple walled latex balloon concept and the signal “spar” buoy performed well in the 50 ft dive tower and advanced to the open-water test.

were evaluated: Mylar, rubber, and triple walled latex. The second balloon concept used a heavy grade flexible polyurethane material with a built in attachment handle. A third concept was to use a COTS signal buoy by Underwater Breathing Systems, Inc. This spar shaped buoy was modified to use a military specification double cartridge CO<sub>2</sub> actuator.

Four anchoring concepts were investigated: A double grappling anchor; auger anchor;

Combinations of the spar buoy, triple walled latex balloon, parachute chord, bungee, auger anchor, and the DUCKBILL anchor with both the slide hammer and aqua-jet insertion tools were tested. Both buoys performed well. However, the spar buoy could be seen from a much farther distance. The DUCKBILL anchor worked well. However the slide hammer insertion tool was difficult to use and exhausted the diver. The aqua-jet insertion tool worked well but the diver complained about having to use his regulator as a power source. The diver because of ease of use preferred the auger anchor. The bungee was considered superior to the parachute chord because it was self-compensating for wave action whereas the parachute chord was not.

The spar buoy, auger anchor, and bungee were given to the VSW/MCM detachment and successfully used in RIMPAC EAST 00. During a pre-exercise trial, the buoys were emplaced in 20 ft of water about ½ mile from NAS North Island, CA, in the Pacific Ocean. Seas were calm, winds 10-15 knots. After 46 hours the buoys were in place and fully inflated and after 96 hours the buoys were still in place but had deflated about 35%. Diver comments were positive but revealed some problems. First, all low-μ components were mandatory, second, a tougher bag material with a reinforced line attachment point was desired, and third a plug was preferred over the oral inflation tube to allow a diver to easily deflate the buoy for reuse.

**Table 1. Combine Notional Marker Characteristics**

| Parameter                  | Value / Attribute   |
|----------------------------|---|
| Detection Range            | <ul style="list-style-type: none"> <li>• <u>Visual</u>: 500 meters (normal day / night conditions)</li> <li>• <u>Sensor</u>: 2000 meters (all conditions, storm, fog)</li> </ul>  |
| Depth/Sea State            | <ul style="list-style-type: none"> <li>• 40' (total including tidal variations)</li> <li>• Sea State 3 <ul style="list-style-type: none"> <li>– Significant wave height 4'</li> <li>– Period 8.6 sec</li> </ul> </li> </ul>   |
| Duration                   | <ul style="list-style-type: none"> <li>• 24 hours (mechanical / electrical)</li> </ul>  |
| Allowable Watch Circle     | <ul style="list-style-type: none"> <li>• 10' at 10' water depth</li> <li>• 20' at 40' water depth</li> </ul>  |
| Application                | <ul style="list-style-type: none"> <li>• Fully functional for Inbound and Outbound Craft</li> <li>• No requirement for supplemental markers on beach</li> <li>• Beach markers utilized <u>after</u> lane breach</li> <li>• Specific deployment platform for marker system is consistent with current concept of breaching operations</li> </ul> |
| Additional Characteristics | <ul style="list-style-type: none"> <li>• System Defines/Differentiates Left and Right lateral limits</li> </ul>   |

The desired modifications were made and tested in the 50-ft dive tower. Several design iterations were made before a successful test was completed. During the first test, the buoy ruptured at the seam. This



**Figure 3. Cypress Springs**

was due to a fault in the manufacturing process. The second test was a success, however the buoy was repacked and tested again. This time it failed. It was concluded that excess air was left in the buoy because of the deflation plug and that the oral inflation tube needed to be reinstalled.

The final design was successfully tested and was demonstration at Cypress Springs, Florida (Figure 3). Figure 4 shows the final buoy design with the exercise auger anchor. The buoy is made of an international orange 200 denier nylon, is 78 in long by 8-inch wide, and is attached to a line via three

points. The buoy also incorporates a radar reflective foil liner, an oral inflation tube, an attachment for a light, and two mil spec 32 gm low- $\mu$  CO<sub>2</sub> cartridges.

We have just approved the final specifications for the low- $\mu$  auger anchor and are waiting for the model to be completed. The final design will have two 8 in long integrated swing handles made of 316 stainless steel. The 10-inch long shaft, 4-inch diameter auger and 3-inch long pigtail will be made of 6061-T6 aluminum. The handles will be attached via a hex head bolt made of 316 stainless steel.

The aqua-jet was redesigned to use a CO<sub>2</sub> cartridge and has a trigger to control the amount of flow. Several tests were conducted in the surf zone with the aqua-jet and a modified DUCKBILL anchor. The anchor has a small whole drilled in the end to allow the gas to pass through into the sand. This design worked well and if made with low- $\mu$  components will be considered a viable alternate to the auger anchor.



**Figure 4. Final Buoy Design**

#### *Inflatable Foam Injected Buoy*



**Figure 5. IFIB one**

Ron Woodfin (LATA) conducted the demonstration. Unit number one was pre-assembled and ready for immediate operation; unit number two was assembled during the course of the demo. When unit one was activated, adequate simultaneity rupture of the chemical reservoir diaphragms occurred. Mixed chemicals were immediately extruded into the envelope. However, because the filling tube was not properly inserted into the envelope about half the material escaped and discharged onto the ground. The result was an incompletely filled envelope (Figure 5).

We therefore decided to prep unit number two for demonstration and ensured that the filling tube was properly inserted. This time poor simultaneity rupture of the chemical reservoir diaphragms occurred. Judging by the sound produced, one diaphragm ruptured about one to one and a half seconds prior to the other. The result was an incompletely filled envelope containing pockets of poorly mixed material as well as proper foam.

#### **IMPACT/APPLICATION**

The DILMS proved to be a success and offers the amphibious assault force a mean to navigate a breached lane that was not previously available. It must be concluded, that the IFIB demonstration was not 100% successful, but that it did achieve its goal of demonstrating concept feasibility. Clearly, some engineering development is needed. A more forgiving timeline of 6-12 months would allow more options to be explored and the foam chemistry to be optimized.

#### **TRANSITIONS**

None for FY00.

## **RELATED PROJECTS**

PMS-EOD has a program planned to begin in FY 2003 to develop a lane marking system deployable by a diver or possibly by a Unmanned Underwater Vehicle.

## **PATENTS**

Jones, A.D., U.S. Navy Case No. 82399, Inflatable Chemical Foam Injected Buoy, 6 June 2000.